Factors Influencing Occurrence, Scale, Mobility, Runout, And Morphology of Mass Movements on the Continental Slope

Jacques Locat
Department of Geology and Geological Engineering
Laval University
Sainte-Foy, Québec, CANADA G1K 7P4
phone: (418) 656 2179 fax: (418) 656-7339 email: locat@ggl.ulaval.ca
Award #: N00014-98-1-0073

LONG-TERM GOAL

Achieve an improved understanding of the relationships between sedimentation, environment, and the morphology of continental slopes. This goal will be accomplished primarily through investigations within the northern California (Eel River) study area and incorporation of data from around the World. An underlying assumption of our work is that the occurrence and morphology of mass movement features on the continental slope depend upon a combination of characteristics, each of which varies over the region in a consistent manner. The various component of this project are part of a concerted effort between the geotechnical groups at the USGS and Laval University. Their activities are very much interwoven but, for administrative reasons, their respective budgets are allowed separately as are the ONR reports.

OBJECTIVES

Identify factors that can be mapped regionally and that determine where and how slope failures occur; derive a basis for producing regional maps that indicate relative landslide susceptibility. Model shear strength development with depth and incorporate this model into continental slope stability, post-failure behavior, and bedform processes. Observe and model pore pressure development in continental slopes. Analyze the relationship between seismic intensity, sediment instability and slope processes.

APPROACH

Our research focuses on the factors that lead to variations in the sedimentological and environmental conditions determining slope failure. We develop improved correlation between engineering classifications and strength factors. We relate compressibility, physico-chemical properties and strength to sediment microstructure, observed using SEM techniques. We simulate sediment accumulation in specially designed large cells. We measure sediment rheological properties in a viscometer. Geotechnical properties are related to sediment density state, obtained from detailed logs of downcore variability of sediment density and sound velocity. Using available bathymetry, we construct slope maps. Seismic shaking variations are evaluated probabilistically by seismologists. In situ pore pressures are determined by means of the Excalibur probe (AGC-Atlantic). These pressures can be generated if the sedimentation rate is particularly rapid, if there is charging by bubble-phase gas, or if earthquake shaking disrupts the sediment fabric and causes it to collapse with a resulting increase in the pressure of interstitial fluids. Driving stresses are balanced against strength variations in a geographic Information System (GIS) to obtain a regional estimate of relative slope stability.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
1998		**00-00-1998 to 00-00-1998**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Factors Influencing Occurrence, Scale, Mobility, Runout, and Morphology of Mass Movements on the Continental Slope	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Laval University of ,Department of Geology and Geological Engineering,Saint-Foy, Quebec, Canada G1K 7P4,**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM002252.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**4**	

Key individuals, at Laval: Jacques Locat, Jean-Marie Konrad, Harold Christian, Éric Boulanger, Prisiclla Desgagnés, Fancis Martin, and Frédéric Laurent: strength and compressibility measurements, SEM studies, rheology measurements, and simulation of sediment accumulation.; at the USGS: Homa Lee, Ken Israel, Pete Dartnell, and Greg Martz: physical property logs of sediment cores and relations between geotechnical and classification properties, algorithms relating sediment properties, environmental factors, and slope stability within the framework of a GIS.

WORK COMPLETED

During an oceanographic cruise to the Eel Margin on the Wecoma, one leg was dedicated primarily to geotechnical objectives (July 16-24, 1998). A group of four scientists came from Laval to join the research team (Locat, Bélanger, Desgagnés and Martin) so as to run an onboard geotechnical testing laboratory in cooperation with IUGS group. For our project, we collected xx box cores and yy Lehigh cores (this equipment was rented from GSC-Atlantic, Halifax). All cores were logged at 1-cm resolution for density, sound velocity, and magnetic susceptibility. Most of the box cores were tested on board for intact and remoulded shear strength and water content. A total of zz sites were surveyed in situ by means of the Excalibur probe which enable measurement of the intersitial pore water down to a depth of 4 meters in the sediments and the collection of 2 gas samples. Further tests conducted at Laval included oedometer tests, SEDCON tests, simple shear tests, Atterberg's limits, grain size, mineralogy, microstructure and rheology. Most of these data are entered into a GIS to evaluate regional variations in sediment properties and environmental loads. Algorithms convert these data into estimates of slope stability. In carrying out the above mentioned work, we participated to one STRATAFORM meeting in Keystone (Colorado) and to one sub-group meeting in Minnesota under with G. Parker, dealing primarily with mud flow rheology and experimental, testing.

RESULTS

Classic slope failure features on the Eel Margin are rare even though our methodology shows a high vulnerability to slope failure during seismic loading, indicating either that mass wasting on the Eel Margin takes unexpected forms or that mass wasting is less significant than would be expected. Studies of shear strength development show a bi-linear function, resulting from bioturbation. Rheological studies of Eel Margin sediment show a highly thixotropic material, represented by a pseudo-Bingham model.

IMPACT/APPLICATION

Relationships developed in this project show the importance of sediment liquidity index and seabed density profiles in representing the behavior of marine sediment. These values can be used to predict regional slope stability and the rheological behavior of debris flows.

TRANSITIONS

Geoacoustic properties are being used by mappers and acousticians to identify lithologies acoustically. Rheological properties are being used by modelers to represent debris flows. Landslide generation models are being used by landscape evolution modelers. Along these lines, a meeting was held at the University of Minnesota with G. Pasrker to interface our activities and research interest on debris flows.

RELATED PROJECTS

Lee has developed a USGS project to investigate sediment and pollutant transport on the Los Angeles margin that uses techniques produced by STRATAFORM. Locat is investigating the behavior of a newly formed sediment layer acting as a natural cap over contaminated sediment in Canada. The development of this project benefited from approaches developed within STRATAFORM.

REFERENCES

Boulanger, É., Locat, J., Desgagnés, P. Martin, F., and Lee, H., 1998. Geotechnical testing of Eel River sediments collected as part of the R/V Wecoma Cruise # W9807A (July 14 – 25th 1998). Department of Geology and Geological Engineering, Laval University, Québec, CANADA, GREGI Report 98-20, 45 p.

Christian, H., 1998. Excalibur pore pressure and fluid sampling, STRATAFORM Wecoma 9807A Cruise. Report submitted to Laval University, 16 p.

Laurent, F., 1997. Analyse de la stabilité des marges continentales. Cas d'une marge active: talus sous marin au large d'Eureka, Californie (Stability analysis of a continental margin, the case of an active margin: a submarine slope off Eureka, California). École nationale des travaux publics et d'état and the Department of Geology and Geological Engineering, Laval University, Bachelor Thesis, 81 p. (plus appendices).

PUBLICATIONS

Boulanger, E., Konrad, J.-M., Locat, J., and Lee, H.J., 1998. Cyclic behaviour of Eel River sediments: a possible explanation for the paucity of submarine landslide features. AGU Fall meeting, San Francisco, Abstracts.

Lee, H.J., Locat, J., Dartnell, P., and Israel, K., Regional variability of slope stability: Application to the Eel Margin, California, Marine Geology (in press).

Lee, HJ., Dartnell, P., Israel, K., Wong, F., and Locat, J., 1998. Evaluating shallow-seated submarine slope stability: comparison between the Eel margin and the Los Angeles margin, California. In: STRATCON '98: "STRATA AND SEQUENCES ON SHELVES AND SLOPES", SEPM-IAS Research Conference, Sicily, September 14-19th 1998, Abstract.

Lee, H.J., , Dartnell, P., Minasian, D., Wong, F., Israel, K., and Locat, J., 1998. Shallow-Seated Slope Stability Contrasts: Eureka, CA vs. Santa Monica Bay, CA. AGU Fall meeting, San Francisco, Abstracts.

Locat, J., 1997. Normalized rheological behaviour of fine muds and their flow properties in a pseudoplastic regime. Debris-Flow Hazards Mitigation: Mechanics, Prediction, and Assessment, Proceedings of the First International conference. Water Resources Engineering Division/ASCE, 1997, pp.: 260-269.

Locat, J., and Lee, H., Structuration and Mobilization of Eel River Margin Sediment: Factors and Behavior (Submitted to the Canadian Geotechnical Journal).

Locat, J., Lee, H.J., Boulanger, É., and Maurice, F., 1998. Rapid sedimentation, the role of bioturbation and shear strength development: comparison between the Eel River Margin (California) and Saguenay Fjord (Québec) sediments. . In: STRATCON '98: “STRATA AND SEQUENCES ON SHELVES AND SLOPES”, SEPM-IAS Research Conference, Sicily, September 14-19th 1998, Abstract.